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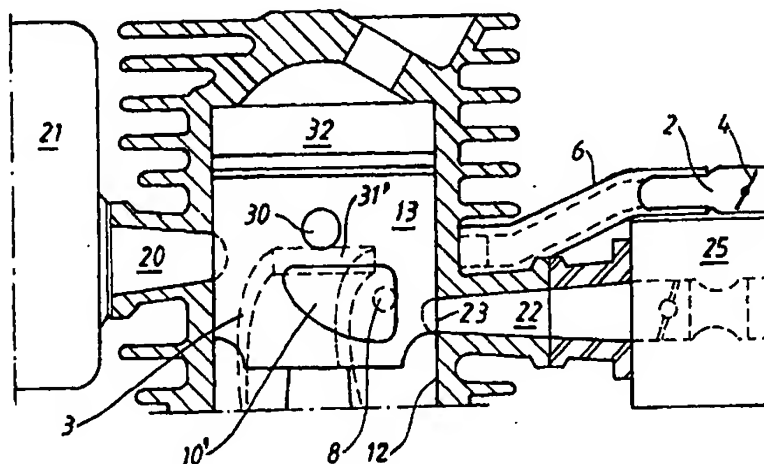
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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>7</sup> : <b>F02B 25/22, 25/14, 33/04</b>		A1	(11) International Publication Number: <b>WO 00/43650</b>
			(43) International Publication Date: <b>27 July 2000 (27.07.00)</b>
(21) International Application Number: <b>PCT/SE00/00056</b> (22) International Filing Date: <b>14 January 2000 (14.01.00)</b> (30) Priority Data: 9900138-0                      19 January 1999 (19.01.99)                      SE (71) Applicant (for all designated States except US): <b>AKTIEBOLAGET ELECTROLUX [SE/SE]; S-105 45 Stockholm (SE).</b> (72) Inventors; and (75) Inventors/Applicants (for US only): <b>ANDERSSON, Lars [SE/SE]; Sjömilsgatan 16, S-421 37 Västra Frölunda (SE). DAHLBERG, Göran [SE/SE]; Bunnström, S-563 92 Gränna (SE). JONSSON, Bo [SE/SE]; Lundgatan 243, S-566 33 Habo (SE). STRÖM, Hans [SE/SE]; Bräcke 14003, S-442 60 Kode (SE).</b> (74) Agents: <b>ANDERSSON, Lars et al.; AB Electrolux, Husqvarna AB, S-433 81 Jönsered (SE).</b>		(81) Designated States: <b>AE, AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</b>  <b>Published</b> <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i> <i>In English translation (filed in Swedish).</i>	

(54) Title: TWO-STROKE INTERNAL COMBUSTION ENGINE



(57) Abstract

Crankcase scavenged two-stroke internal combustion engine (1), in which a piston ported air passage is arranged between an air inlet (2) and the upper part of a number of transfer ducts (3, 3'). The air inlet is equipped with a restriction valve (4), controlled by at least one engine parameter, for instance the carburettor throttle control. The air inlet extends via at least one connecting duct (6, 6') to at least one connecting port (7, 7') in the engine's cylinder wall (12). The connecting port (7, 7') is arranged so that it, in connection with piston positions at the top dead centre, is connected with flow paths (9, 9') embodied in the piston (13), which extend to the upper part of a number of transfer ducts (3, 3'), and the flow paths in the piston are so arranged that the recess (9, 9'; 10, 10'; 11, 11') in the piston that meets the respective transfer duct's port (31, 31') is so arranged that the air supply is given an essentially equally long or longer period, counted as crank angle or time, in relation to the inlet.

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## TWO-STROKE INTERNAL COMBUSTION ENGINE

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### Technical field

The subject invention refers to a two-stroke crankcase scavenged internal combustion engine, in which a piston ported air passage is arranged between an air inlet and the upper part of a number of transfer ducts. Fresh air is added at the top of the transfer ducts and is intended to serve as a buffer against the air/fuel mixture below. This buffer is mainly lost out into the exhaust outlet during the scavenging process. The fuel consumption and the exhaust emissions are thereby reduced. The engine is foremost intended for a handheld working tool.

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### Background of the invention

Combustion engines of the above mentioned kind are known. They reduce the fuel consumption and exhaust emissions, but it is difficult to control the air/fuel ratio in such an engine. US 4,075,985 shows an example of a two-stroke engine where air ducts connect to the upper part of the engine's transfer ducts. Check valves are arranged at the connection between the ducts. A restriction valve is arranged in the air supply system to the transfer ducts. This is mechanically connected to the throttle valve of the carburettor of the engine, so that the two valves are following each other.

US 5,425,346 shows an engine with a somewhat different design than the above mentioned. In this case, channels are arranged in the piston of the engine, which at specific piston positions are aligned with ducts arranged in the cylinder. Fresh air, as shown in figure 7, or exhaust gases can thereby be added to the upper part of the transfer ducts. This only happens at the specific piston positions where the ducts in the piston and the cylinder are aligned. This happens both when the piston moves downwards and when the piston moves upwards far away from the top dead centre. To avoid unwanted flow in the wrong direction in the latter case, check valves are arranged at the inlet to the upper part of the

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transfer ducts. In this respect it consequently corresponds to the previously mentioned patent. This type of check valves, usually called reed valves, has however a number of disadvantages. They have frequently a tendency to come into resonant oscillations and can have difficulties to cope with the high rotational speeds that many two-stroke engines can reach. Besides, it results in added cost and increased number of engine components. Should such a valve break into smaller pieces, then these can enter into the engine and cause severe damages. The amount of fresh air added is, for the solution according to the latter patent, varied by means of a variable inlet, i.e. an inlet that can be advanced or retarded in the work cycle. This is however a very complicated solution.

The international patent application W098/57053 shows a few different embodiments of an engine where air is supplied to the transfer ducts via L-shaped or T-shaped recesses in the piston. Thus, there are no check valves. In all embodiments the piston recess has, where it meets the respective transfer duct, a very limited height, which is essentially equal to the height of the actual transfer port. A consequence of this embodiment is that the passage for the air delivery through the piston to the transfer port is opened significantly later than the passage for the air/fuel mixture to the crankcase is opened by the piston. The period for the air supply is consequently significantly shorter than the period for the supply of air/fuel mixture, where the period can be counted as crank angle or time. This means that the amount of air that can be delivered to the transfer duct is significantly limited, since the underpressure driving this additional air has decreased a lot, because the inlet port has already been open during a certain period of time when the air supply is opened. This implies that both the period and the driving force for the air supply are small. Furthermore, the flow restriction in the L-shaped and the T-shaped ducts as shown becomes relatively high, partly because the cross section of the duct is small close to the transfer port and partly because of the abrupt bend created by the L-shape or T-shape. In all, this contributes to reducing the amount of air that can be delivered to the transfer ducts, which reduces the possibilities to reduce the fuel consumption and the exhaust emissions by means of this arrangement.

**The purpose of the invention**

The purpose of the subject invention is to significantly reduce the above mentioned problems and to achieve advantages in many respects.

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**Summary of the invention**

The above mentioned purpose is achieved by a two-stroke combustion engine in accordance with the invention showing the characteristics of the appended patent claims.

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The combustion engine in accordance with the invention is thus essentially characterized in that the air passage is arranged from an air inlet equipped with a restriction valve, controlled by at least one engine parameter, e.g. the carburettor throttle control, the mentioned air inlet is via at least one connecting duct channelled to at least one connecting port in the cylinder wall of the engine, which is arranged so that it, in connection with piston positions at the top dead centre, is connected with flow paths embodied in the piston, which extend to the upper part of a number of transfer ducts, and the flow paths in the piston are so arranged that the recess in the piston that meets the respective transfer duct's port is so arranged that the air supply is given an essentially

20 equally long or longer period, counted as crank angle or time, in relation to the inlet.

Because at least one connecting port in the engine's cylinder wall is arranged so that it in connection with piston positions at the top dead centre is connected with flow paths embodied in the piston, the supply of fresh air to the upper part of the transfer ducts can be arranged entirely without check valves.

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This can take place because that at piston positions at or near the top dead centre there is an underpressure in the transfer duct in relation to the ambient air. Thus a piston ported air passage without check valves can be arranged, which is a major advantage. Because the air supply has a very long period, a lot of air can be delivered, so that a very high exhaust emissions reduction effect can be achieved.

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Control is applied by means of a restriction valve in the air inlet, controlled by at least one engine parameter. Such control is of a significantly less complicated design than a variable inlet. The air inlet has preferably two connecting ports, which in one embodiment are so located that the piston is covering them at its

bottom dead centre. The restriction valve can suitably be controlled by the engine speed, alone or in combination with another engine parameter. These and other characteristics and advantages are clarified in the detailed description of the different embodiments, supported by the enclosed drawing figures.

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### **Brief description of the drawing**

The invention will be described in closer detail in the following by means of various embodiments thereof with reference to the accompanying drawing figures. For parts that are symmetrically located on the engine, the part on the one side has been given a numeric designation while the part on the opposite side has been given the same designation but with a '-symbol.

Figure 1 shows a side view of a first embodiment of the subject invention. The cylinder is shown in a cross section, while the piston from a clarity point of view is not shown in a cross section, and is shown at the top dead centre.

Figure 2 shows the engine according to figure 1 in cross section along line II - II. This is consequently a cross section shown from above through the engine's exhaust outlet, transfer duct's ports and through the entire air inlet.

Figure 3 shows a cross section similar to that in figure 1, but in a different embodiment. The piston and the flow paths in the piston and the cylinder are differently designed. The piston is also shown in a position below the top dead centre.

Figure 4 shows a somewhat different embodiment than that shown in figure 3. The flow path in the piston is laid out by means of a duct arranged in the piston. The piston is shown at the top dead centre.

Figure 5 shows a cross section through the piston and the cylinder through a connecting port for air to the transfer duct.

Figure 6 shows schematically a control device for a restriction valve. From a clarity point of view, it is shown located far below the real location.

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### **Description of embodiments**

In figure 1, numeral reference 1 designates an internal combustion engine according to the invention. It is of two-stroke type and has transfer ducts 3, 3'. The latter is not visible since it is located above the plane of the paper. It is

however shown in figure 2. The engine has a cylinder 15 and a crankcase 16, a piston 13 with a connecting rod 17 and a crank mechanism 18. Furthermore, it has an exhaust outlet 19, that has an exhaust port 20 and that ends in a muffler 21. Furthermore, the engine has an inlet tube 22 with an inlet port 23 and an, to the inlet tube connected, intermediate section 24, which in turn connects to a carburettor 25 with a throttle valve 26. The carburettor connects to an inlet muffler 27 with a filter 28. The piston 13 is connected to the connecting rod 17 by means of a piston pin 30. It has a plane upper side without any recesses or similar, so that it co-operates equally with the cylinder ports wherever they are located around the periphery. The height of the power head is therefore approximately unchanged in comparison with a conventional engine. The transfer ducts 3 and 3' have ports 31 and 31' in the engine's cylinder wall 12. The engine has a combustion chamber 32 with an attachment point 33 for a spark plug, which is not shown. All of this is conventional and is therefore not further commented.

What is special is that an air inlet 2 equipped with a restriction valve 4 is arranged so that fresh air can be supplied to the cylinder. The air inlet 2 is divided into two branches, connecting duct 6 and 6'. These are channelled to the cylinder, which is equipped with connecting ports 7, 7'. These connecting ports are shaped as a cylindrical hole, each with a fitted connecting nipple 34, 34'. By connecting port is from now on meant the port of the connection on the inside of the cylinder, while its port on the outside of the cylinder is called the outer connecting port. This is clearly shown in figure 2 in combination with figure 1. The air inlet 2 is suitably designed as a y-shaped tube, while the connecting ducts for example are suitably made of rubber hoses. The air inlet 2 suitably connects to the inlet muffler 27, so the cleaned fresh air is taken in. If the requirements are lower, this is of course not necessary.

Flow paths 9, 9' are arranged in the piston so that they, in connection with piston positions at the top dead centre, connect the respective connecting port 7, 7' to the upper part of the transfer ducts 3, 3'. The flow paths 9, 9' are made by means of local recesses in the piston. As shown in figure 2, the piston is simply manufactured, usually cast, with these local recesses. As illustrated in figure 1, there is a small height difference between the vertical positions of connecting port 7 at the inside and the outside of the cylinder. This is of course possible, but unnecessary and unsuitable since the distance between the

connecting ducts 6 and 6' is so large that there is no interference from the inlet tube 22. Thus they can be located entirely to the side of the inlet tube, if applicable. The level difference in figure 1 is entirely explained by the fact that it is easier to clearly visualise the connecting duct 6 completely above the inlet tube 22. The air inlet has suitably at least two connecting ports 7, 7' in the engine's cylinder wall 12. Another advantage is that the recesses in the piston 9, 9' hereby can be made smaller sideways. Alternatively, it is indeed possible to have only one connection duct. This should then be entered either above or below the inlet tube 22 or below the exhaust outlet 19. To obtain the wanted vertical position for the corresponding connecting port 7, an oblique passage through the cylinder wall would probably have to be arranged. Hereby only one connecting duct and only one outer connecting port would be required, but it would otherwise result in a number of disadvantages. The sideways positioning of the two connecting ports 7, 7' in relation to the respective transfer ducts 3, 3' can be varied considerably. They can for instance be drawn closer to the transfer duct so that the relative distance between the connecting ducts 6, 6' is increased. In that way the size of the recesses 9, 9' can be somewhat reduced. The connecting ports 7, 7' can also be located on the opposite side of the respective transfer ducts, i.e. between the transfer duct and the exhaust outlet 19. It is of course also possible to place connecting ports on both sides of the respective transfer ducts. This becomes more complicated and implies in total four connecting ducts, but would entail that larger amounts of air can be supplied. To obtain a satisfactory result from an emissions and fuel consumption point of view, it is important that the fresh air is delivered with a minimum of turbulence, i.e. that it to a minimum extent mixes with the air/fuel mixture in the respective transfer duct. The purpose is, as mentioned, that the fresh air shall act as a buffer which depresses the air/fuel mixture, so that subsequently the fresh air is lost out into the exhaust port instead of the air/fuel mixture. The solution illustrated in figures 1 and 2 is however in this respect a hybrid. When the piston 13 is located at its bottom dead centre, the entire exhaust port 20 is open as well as the ports 31, 31' of the transfer ducts and the connecting ports 7, 7' for the fresh air.

This means that exhaust gases can be pressed in through the connecting ports and further on up through the connecting ducts 6, 6' and possibly reach the air inlet 2. This is suitably designed so that a moderate amount of exhaust gas is added to the

fresh air. If too much exhaust gas flows upstream, the carburettor function may be disturbed and in extreme cases the air filter 28 may of course get dirty.

Moderation of the amount of exhaust gas is done by means of moving the respective connecting port 7, 7' downwards. Its location determines the period of time available for the exhaust gases to be in contact with the respective connecting port. In figures 3 and 4, the connecting ports 8, 8' have been moved so far down that they do not come in contact with the exhaust gases at all when the piston is at its bottom dead centre. Instead the piston seals so that this connection does not occur.

10               When the connecting ports 7, 7' are lowered, the recesses 9, 9' must be given increased height in the axial direction of the piston. The recess is obviously intended to be a connection between the connecting port 7, 7' and the respective port 31, 31' of the transfer ducts. This clearly appears from a comparison with figure 3. With the embodiment according to figure 1, a flow path  
15 is created when connecting port 7 and port 31 of the transfer duct respectively close to the top dead centre start to become connected with each other by means of the piston recess 9. The size of the connection between the two reaches its maximum at the top dead centre, subsequently being reduced as the piston moves away from the top dead centre in the opposite direction. In figure 1, port 23 of the  
20 inlet duct is opened earlier than the connecting port 7 is opened by the recess 9. Thus, the underpressure in the crankcase starts to be evened out even before the flow path between the air inlet 2 and the transfer duct is opened. This entails that a limited amount of gases from the air inlet 2 can penetrate down into the transfer duct 3. The opposite situation prevails in figure 3. The piston is drawn in a  
25 location a certain distance away from the top dead centre. This piston location is characterised by the inlet port 23 not having opened but is about to do so. On the contrary, the communication between the air inlet 2 and the transfer ducts 3, 3' has already been opened and been going on during a short piston movement. The underpressure in the crankcase is consequently at its maximum during this initial  
30 period of time, subsequently starting to diminish as the connection between the inlet tube 22 and the crankcase 16 is established. In this case, more gas from the air inlet 2 can consequently be transported down into the transfer ducts. It is desirable that both transfer ducts 3, 3' are entirely filled with such buffer gas. On the other hand, it is not desirable that the supply is noticeably greater than that,

since it will then only dilute the air/fuel mixture in the crankcase. The air supply has consequently been given a longer period, counted as crank angle or time, than the inlet. In the other illustrated embodiments, the inlet period is instead longer. It is often desirable that the inlet period and the air period are essentially equally long. Suitably the air period should be between 90 % - 110 % of the inlet period. In figure 3, this should be achieved by means of the upper edge of the recess 10, 10', which meets the respective port 31, 31' of the transfer ducts, being lowered so that it becomes aligned with the lower edge of the transfer port. These periods are obviously both limited by the maximum period, during which the crankcase pressure is low enough to enable maximum inwards flow. Both periods are preferably maximised and equally long. The location of the upper edge of the recess 10, 10' consequently determines how early the recess gets connected with the respective ports 31, 31' of the transfer ducts. Thus, suitably the recess 9, 9'; 10, 10'; 11, 11' in the piston, which meets the respective ports 31, 31' of the transfer ducts, has, locally at this port, an axial height that is more than 1.5 times the height of the respective port of the transfer ducts, preferably more than 2 times the port height of the transfer duct. The precondition is that the port has normal height, so that the upper side of the piston, when at its bottom dead centre, is aligned with the lower side of the transfer port or extends upwards a few millimetres. In figure 3, the recess 10, 10' has a triangular type of shape, which implies that its height at the transfer port varies, which in turn means that the above mentioned relation in this case should be seen as an average. The recess 10, 10' can naturally instead be given a rectangular shape, so that its lower edge is aligned with the lower edge of the described recess 10, 10'. Its left edge can be aligned with the corresponding edge of the port 31, 31'. The flow restriction could consequently be somewhat reduced.

The recess is preferably downwards shaped in such a way that the connection between the recess 10, 10' and the connecting port 8, 8' is maximised, since it reduces the flow resistance. This means that when the piston is located at its top dead centre, the recess 10, 10' preferably reaches so far down that it does not cover the connecting port 8, 8' at all. If the piston in figure 3 is lowered slightly, so that the upper edge of the recess 10, 10' aligns with the lower edge of the scavenging port 31, 31', it is evident that the recess 10, 10' at the connecting port 8, 8' reaches above the port with a broad margin. This entails that the

connection between the piston recess 10, 10' and the connecting port 8, 8' starts to open earlier than, and becomes maximum before, the connection between the piston recess and the scavenging port 31, 31' is opened. Hereby, the sensitivity to various production tolerances is reduced as well as the air flow resistance to a certain degree. As a whole, this means that the recess 9, 9'; 10, 10'; 11, 11' in the piston that meets each connecting port 7, 7'; 8, 8' respectively locally at this port, has an axial height which is greater than 1.5 times the height of the respective connecting port, but preferably greater than 2 times the height of the connecting port. Thus, in the embodiment according to figure 3, the connecting port(s) 8, 8' in the cylinder wall 12 of the engine is located so that the piston 13 covers them when it is located at its bottom dead centre. Consequently, exhaust gases cannot penetrate into the air inlet at the bottom dead centre.

The relative location of the connecting port 7, 7'; 8, 8' and the transfer duct's port 31, 31', or scavenging port 31, 31', in an axial direction, can be varied considerably provided that the ports are shifted sideways, i.e. in the cylinder's tangential direction, as shown in figures 1, 3 and 4. Figure 1 illustrates a case where the connecting port and the scavenging port 31, 31' are located at the same level, while figures 3 and 4 show solutions where the connecting ports are located at a considerably lower level than the scavenging port. As mentioned, all intermediate locations are plausible. Even when the connecting port(s) is covered by the piston at its bottom dead centre, it may be advantageous to have an axial overlap between the connecting port and the scavenging port, i.e. that the upper edge of each connecting port respectively is located as high or higher in the cylinder's axial direction as the lower edge of each scavenging port respectively. One advantage is that the two ports are more aligned with each other in an arrangement of this kind, which reduces the flow resistance when air is being transported from the connecting port to the scavenging port. Consequently, more air can be transported, which can enhance the positive effects of this arrangement, i.e. reduced fuel consumption and exhaust emissions. For many two-stroke engines, the piston's upper side is level with the lower edge of the exhaust outlet and the lower edge of the scavenging port, when the piston is at its bottom dead centre. However, it is also quite common for the piston to extend a millimetre or few above the scavenging port's lower edge. If the lower edge of the scavenging port is further lowered, an even greater axial overlap will be created between the

connecting port and scavenging port. When air is supplied to the scavenging duct, the flow resistance is now reduced, both due to that the ports are more level with each other and also due to the greater surface area of the scavenging port.

In the embodiments according to figures 1, 2 and 3, the flow paths in the piston are shaped in the form of recesses in the piston's periphery. However, it is also possible to design the flow paths in the piston in the form of at least one duct 14, 14'. This is evident from figure 4. An upper and a lower recess 11' are joined via a duct which runs inside the piston. This becomes more complicated than the solution in accordance with figure 3, but may provide a calmer flow of gas or air from the connecting port 8' across to the upper part of the corresponding transfer duct 3'. If the upper recess 11, 11', which meets the respective transfer duct's port 31, 31', is given a greater height by raising its upper edge axially, the air supply can then be given a period that is as long or longer than the inlet. If the duct has full width as illustrated, the embodiment can then be regarded as solely a duct, but the duct can also have a smaller width and in that case it would be more suitable to regard it as a duct with two recesses at the piston's surface. Even in the embodiment illustrated in figures 1 and 2, the communication can take place in the form of a duct or for instance a recess and a duct, or two recesses and a duct. It can be especially interesting to use combinations with one duct when only one single connecting port 6 is used. Thus, for all the embodiment variants apply that the flow paths are either, at least partly, carried out in the form of at least one recess in the piston's periphery, or alternatively that the flow paths in the piston are, at least partly, carried out in the form of at least one duct inside the piston. In the embodiment according to figure 4, the connecting port 8, 8' is located lower than the exhaust port 20. Thereby, the piston seals at its bottom dead centre so that exhaust gases cannot penetrate in through the connecting port. Figure 5 illustrates an especially interesting positioning of the connecting port 7, 7'. It is located essentially inside an adjacent transfer duct 3, 3', so that the connecting port essentially debouches under the transfer duct's port 31, 31'. Since the connecting port uses the space inside the transfer duct, the recess 10, 10' and/or the duct 14, 14' can be made particularly narrow in the sideways direction, which is an advantage.

What the illustrated embodiments have in common is that the flow path from the air inlet 2 to the upper part of the transfer duct 3, 3' is carried out

entirely without a check valve. This is, as already mentioned, a great advantage, but at the same time it is naturally possible to use a check valve in special embodiments. The invention has been exemplified with an engine with two transfer ducts 3, 3', but naturally it can also have a different number of ducts, for instance four, which is common. Five ducts or even one duct is of course also plausible. Normally the flow paths in the piston shall extend to the upper part of all of the transfer ducts in the different embodiment examples. However, it is also possible that the flow paths only extend to the transfer ducts which are located closest to the exhaust outlet 19. The flow paths, which have been illustrated in the various embodiment examples, are primarily intended for the stated purpose. However, the favourable duct locations as illustrated, are naturally also useful for kindred purposes. One example of this can be that the air inlet 2, the connecting ducts 6 and the flow paths in the piston are instead used for adding cooled exhaust gases to the upper part of the transfer ducts. Another example is that certain transfer ducts are supplied with a rich mixture.

One great difficulty in connection with the usage of the above described design is to control the air/fuel ratio of the engine. This is suitably carried out by means of the restriction valve 4. At idling, the valve shall be completely or almost completely closed and then open at higher engine speeds. The transition can occur suddenly by means of the valve snapping over or opening gradually more and more. The latter function can be achieved by joining the throttle valve 26 and the restriction valve 4. In this case, the restriction valve 4 is solely guided by the throttle valve position. It has however been found that engine load variations tend to result in unacceptable variations in the air/fuel ratio. This problem can be avoided by letting the restriction valve 4 be controlled by the engine speed, so that the valve is essentially closed at idling and then opened at engine speeds above a specified, low engine speed. A solution of this type is illustrated schematically in figure 6. The figure also shows that the restriction valve is also controlled by at least one additional engine parameter, apart from the engine speed, in this case the throttle valve position. However, the additional parameter can also be the underpressure in the engine's inlet tube. An engine speed dependent torque or force transducer 46 can be arranged in a number of different ways, but is here shown relatively schematically. It is described in closer detail in the Swedish patent application no. 9900139-8, which is filed

simultaneously. The engine speed dependent transducer 46 consists of a, together with the crankshaft, rotating disc or cup 35 made of aluminium or similar, for instance the flywheel. One or two segments 36, 37, equipped with permanent magnets, can be turned in the direction of rotation in accordance with arrow 38 or 39 respectively against a spring force. The two segments can be movable separately or joined so that they turn together, essentially around the rotational centre of the disc or the cup 35. A cable 40 is attached to the segment 36 in one end and influences the restriction valve 4 with its other end. A pulley 41, with a variable unrolling radius, is mounted to the shaft 47 of the restriction valve 4. The system allows substantial variation possibilities for the opening, closing and restricting functions of the valve. Naturally, the cable can also act directly on a simple lever instead of the pulley 41, if these great variation possibilities are not wanted. The restriction valve 4 is suitably closed or almost closed at idling, and will start opening at a specified engine speed above that. Suitably, the opening takes place gradually. The valve can possibly also over-rotate so that it starts throttling at overspeeds, i.e. that it rotates further than the point at which it gives the least possible flow resistance in the air inlet 2. The restriction valve 4 could hereby also act as a protection against overspeeding by means of enriching the air/fuel mixture. This engine speed dependent control can also be combined with a control that is dependent on the throttle valve position. In this case, the cable 42 is attached either to a pulley 43 or a lever, attached to the shaft of the restriction valve 4. The other end of the cable is attached to the throttle linkage 45 via a tensile spring 44. Thus, by means of the cable 40, the restriction valve 4 is influenced by an engine speed dependent, rotational force and, via the cable 42, by a throttle valve position dependent, co-operative, rotational force. In other words, the restriction valve 4 is in a torque equilibrium between the mentioned, rotational torques and the torque from a return spring, i.e. a force equilibrium system. Alternatively, one could consider a position defined system, where a speed controlled, electric control device turns the restriction valve 4 on its own, or in combination with a linkage connected to the throttle valve position. If an electric control device is used, it will naturally have to be supplied with power from the engine itself, while the illustrated engine speed dependent transducer 46 is self-supporting and in that respect simpler. If an electric control device is used, it is easy to detect different, suitable engine parameters, even underpressure in the

inlet tube, and feed these into a micro computer, from which to give signals for suitable manoeuvring of the restriction valve 4.

The restriction valve 4 can also be controlled by the underpressure which prevail in the engine's inlet tube, so that the valve is essentially closed at idling, to be opened at an underpressure less than a specified underpressure. The underpressure in the engine's inlet tube can affect a small cylinder, which by itself or via an intermediate element influences the restriction valve 4. In a corresponding way as in the example given above concerning the engine speed and the throttle valve position, the control of the underpressure can also be weighed together with an additional engine parameter, such as the throttle valve position and the engine speed.

The different methods, as described above, to control the restriction valve 4, co-operate with the piston control of the flow path from the air inlet to the respective transfer duct in order to provide the correct amount of air or gas at different engine speeds and loads. However, by means of a somewhat different tuning of the restriction valve control, the different, described control methods also ought to be able to co-operate with flow paths that are controlled by check valves.

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PATENT CLAIMS

1. Crankcase scavenged two-stroke internal combustion engine (1),  
in which a piston ported air passage is arranged between an air inlet (2) and the  
upper part of a number of transfer ducts (3, 3'), characterized in that the air  
5 passage is arranged from an air inlet (2) equipped with a restriction valve (4)  
controlled by at least one engine parameter, for example the carburettor throttle  
control, the air inlet extends via at least one connecting duct (6, 6') to at least one  
connecting port (7, 7'; 8, 8') in the cylinder wall (12) of the engine, which is  
arranged so that it, in connection with piston positions at the top dead centre, is  
10 connected with flow paths (9, 9'; 10, 10'; 11, 11') embodied in the piston (13),  
which extend to the upper part of a number of transfer ducts (3, 3'), and the flow  
paths in the piston are so arranged that the recess (9, 9'; 10, 10'; 11, 11') in the  
piston that meets the respective transfer duct's port (31, 31') is arranged so that  
the air supply is given an essentially equally long or longer period, counted as  
15 crank angle or time, in relation to the inlet.

2. Crankcase scavenged combustion engine (1) in accordance with  
patent claim 1, characterized in that the period of the air supply is greater  
than 90 % of the inlet period but smaller than 110 % of the inlet period.

3. Crankcase scavenged combustion engine (1) in accordance with  
20 patent claim 1 or 2, characterized in that the recess (9, 9'; 10, 10'; 11, 11')  
in the piston that meets the respective transfer duct's port (31, 31') locally at this  
port has an axial height that is greater than 1.5 times the height of the respective  
transfer duct's port (31, 31'), preferably greater than 2 times the height of the  
transfer duct's port.

25 4. Crankcase scavenged combustion engine (1) in accordance with  
any of the preceding patent claims, characterized in that the upper edge of  
the respective connecting port (7, 7'; 8, 8') is located as high or higher in the  
cylinder's axial direction than the lower edge of the respective transfer duct's port  
(31, 31').

30 5. Crankcase scavenged combustion engine (1) in accordance with  
any of the preceding patent claims, characterized in that the air inlet (2)  
has at least two connecting ports (7, 7'; 8, 8') in the engine's cylinder wall (12).

6. Crankcase scavenged combustion engine (1) in accordance with  
any of the preceding patent claims, characterized in that the connecting

port(s) (8, 8') in the engine's cylinder wall (12) are so located that the piston (13) covers them when it is positioned at its bottom dead centre.

7. Crankcase scavenged combustion engine (1) in accordance with patent claims 1-4, characterized in that the connecting port(s) (7, 7') in the engine's cylinder wall (12) are located so that the piston (13) does not cover them when it is positioned at its bottom dead centre, but exhaust gases from the cylinder can penetrate into the air inlet.

8. Crankcase scavenged combustion engine (1) in accordance with any of the preceding patent claims, characterized in that the flow paths (9, 9'; 10, 10'; 11, 11') in the piston at least partly are arranged in the form of at least one recess (9, 9'; 10, 10'; 11, 11') in the periphery of the piston.

9. Crankcase scavenged combustion engine (1) in accordance with any of the preceding patent claims, characterized in that the flow paths (11, 11') in the piston at least partly are arranged in the form of at least one duct (14, 14') within the piston.

10. Crankcase scavenged combustion engine (1) in accordance with patent claims 6, 8 or 9, characterized in that at least one connecting port (8, 8') is located essentially inside an adjacent transfer duct (3, 3'), so that the connecting port debouches essentially below the transfer duct's port (15, 15').

11. Crankcase scavenged combustion engine (1) in accordance with any of the preceding patent claims, characterized in that the restriction valve (4) is controlled by the engine's rotational speed, so that the valve is essentially closed at idling, to be opened at rotational speeds exceeding a given low rotational speed.

12. Crankcase scavenged combustion engine (1) in accordance with patent claim 11, characterized in that the restriction valve (4) besides the engine speed also is controlled by at least one further engine parameter, such as the carburettor throttle valve position and the underpressure in the engine's inlet tube.

13. Crankcase scavenged combustion engine (1) in accordance with any of the preceding patent claims 1-10, characterized in that the restriction valve (4) is controlled by the underpressure that prevails in the inlet tube of the engine, so that the valve is essentially closed at idling, to be opened at underpressures below a certain given underpressure.

14. Crankcase scavenged combustion engine (1) in accordance with patent claim 13, characterized in that the restriction valve (4) besides the underpressure also is controlled by at least one further engine parameter, such as the carburettor throttle valve position and the engine speed.

5 15. Crankcase scavenged combustion engine (1) in accordance with any of the preceding patent claims, characterized in that the flow paths (9, 9'; 10, 10'; 11, 11') in the piston (13) extend to the upper part of all the transfer ducts (3, 3').

10 16. Crankcase scavenged combustion engine (1) in accordance with any of the preceding patent claims, characterized in that the flow path from the air inlet (2) to the upper part of the respective transfer duct (3, 3') is arranged entirely without any check valve.

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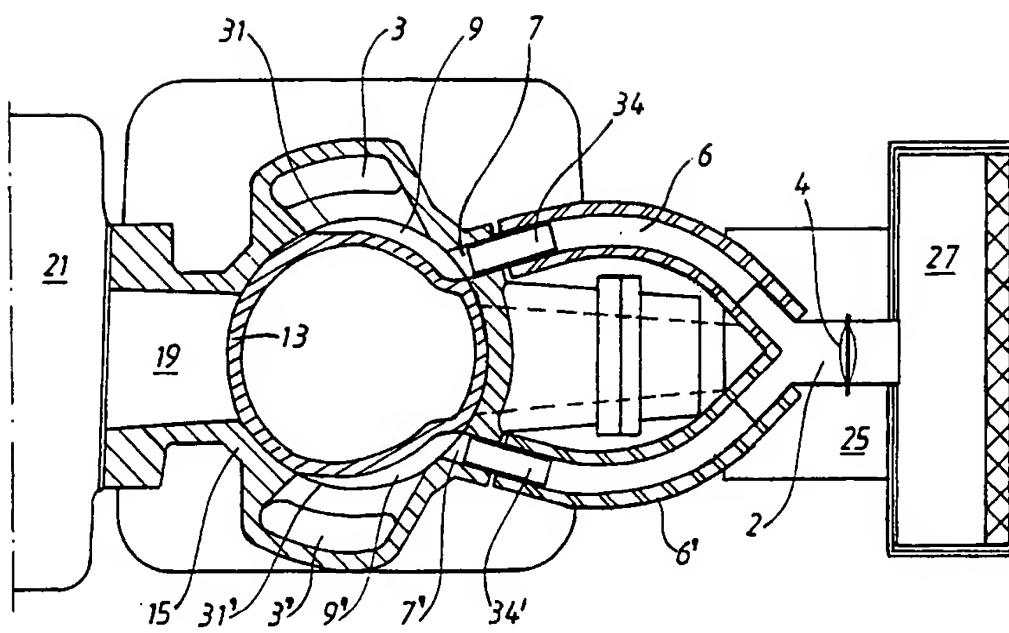


FIG. 2

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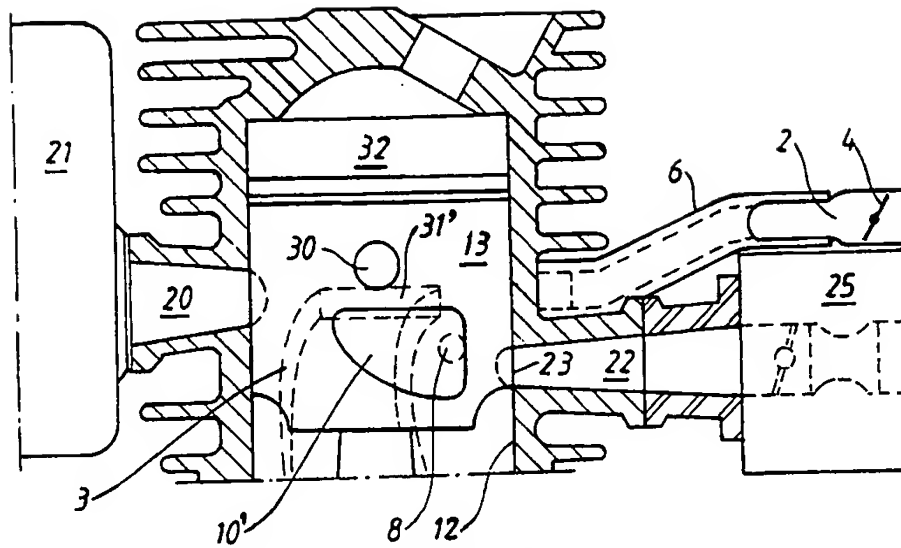


FIG. 3

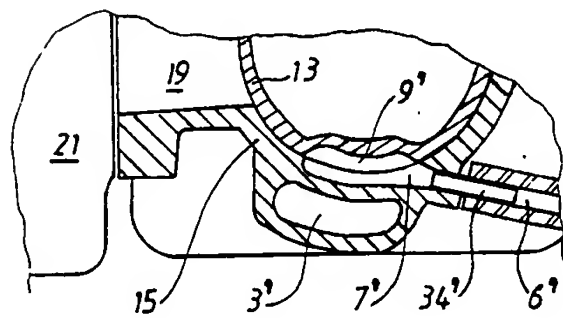


FIG. 5

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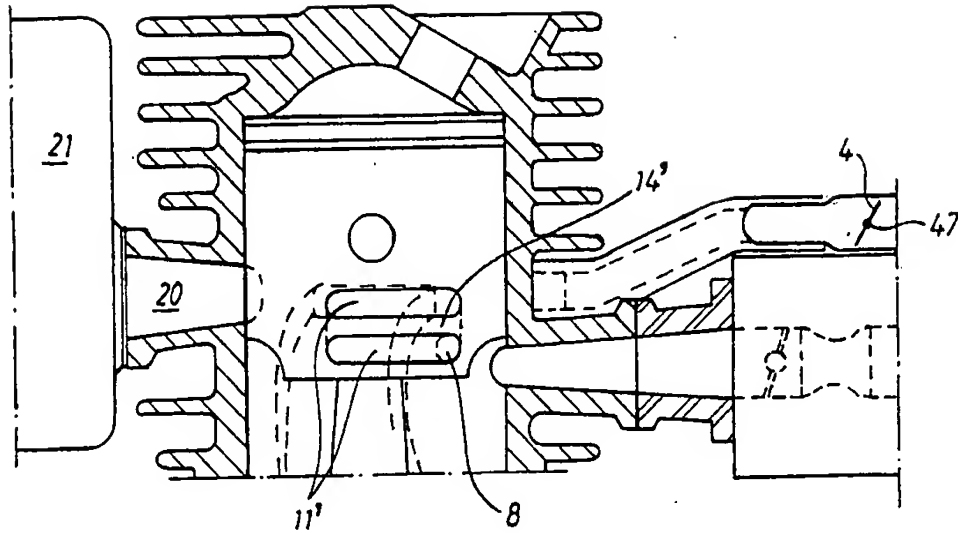


FIG. 4

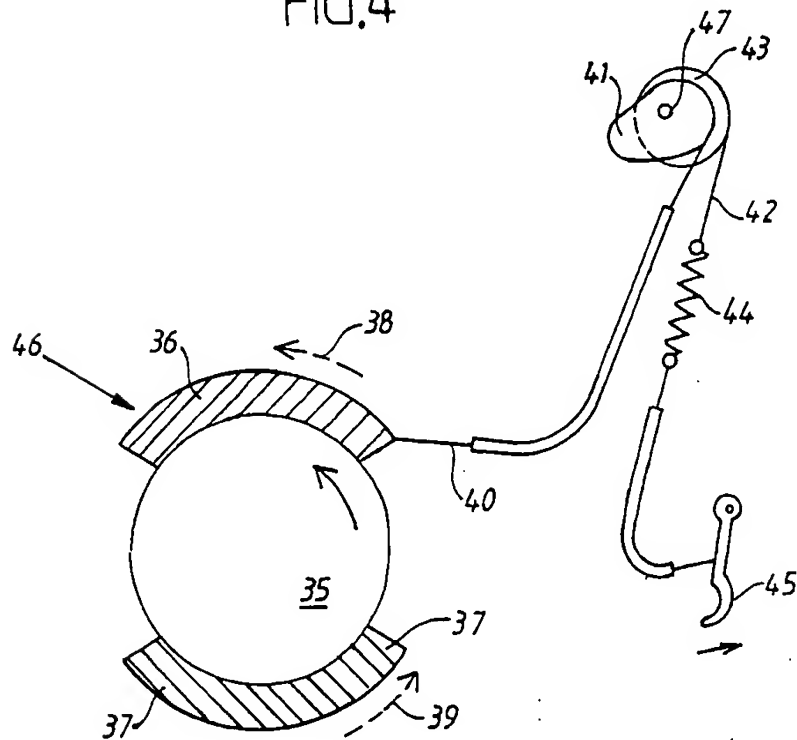


FIG. 6

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 00/00056

## A. CLASSIFICATION OF SUBJECT MATTER

IPC7: F02B 25/22, F02B 25/14, F02B 33/04

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: F02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4075985 A (IWAI), 28 February 1978 (28.02.78), column 3, line 21 - column 4, line 55, figures 1,2, abstract --	
A	US 5425346 A (MAVINAHALLY), 20 June 1995 (20.06.95), column 3, line 20 - column 4, line 52, figures 1-4, abstract --	
A	Patent Abstracts of Japan, Vol 7, No 29, M-191 abstract of JP 57-183520 A (ISAO ODA), 11 November 1982 (11.11.82), abstract --	

☒ Further documents are listed in the continuation of Box C.
 ☒ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

19 April 2000

Date of mailing of the international search report

15 -05- 2000

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 00/00056

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4253433 A (BLAIR), 3 March 1981 (03.03.81), column 1, line 58 - column 3, line 24, figures 1-2, abstract  --	
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**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

02/12/99

International application No.  
PCT/SE 00/00056

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